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Marginal Land-based Biomass Energy Production in Yellow River Delta

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Abstract. Energy crops are not only the key to the development of biomass energy, but also can promote the improvement of saline and other marginal land and mprove the utilization efficiency. The rural biomass energy utilization status and characteristics of different energy crops and research status in Yellow River Delta was introduced; Castor, switchgrass and sweet sorghum grown in marginal land feasibility are discussed; Finally, the several suggestions of to promote biomass energy and local marginal land development have been proposed.

Introduction

Yellow River Delta is located in the south coast of Bohai bay and in the west coast of Laizhou bay, mainly in Dongying and Binzhou city, China. The total area of Yellow River Delta is about 1.75 million hectares, and there is 0.303 million hectares unused saline alkali soil in this area. . Marginal land resources in the Yellow River delta is rich, which accounts for as high as 70 percent or above of the saline alkali land[1]. Combined marginal land development and biomass energy meets the principle of "Can't compete with people for the grain, can't compete with grain for farmlad" and it help to promote the full development of marginal land.

Biomass is an emerging energy, which is based on organic wastes of agriculture and forestry and energy crops planted on marginal land[2]. Its characteristics are renewable and low pollution with widely distribution as an abundant rawmaterials. In China, the annual biomass power generation capacity reached 5.5 million kilowatts; bio-fuel ethanol production was 2 milion tons per annum; the rural household biogas utilization reached 19 billion cubic meters, about 500 million tons of standard coal equivalent[3,4]. It is reported that by 2020, 20 percent of U.S. transportation fuels would come from biofuels, and the same period China will reach 15%, while Sweden would be close to 100%[5,6]. The development and utilization of modern biomass energy technology has a very important significance for alleviating the energy crisis and environmental protection.

Development Situations

The utilization of rural biomass energy in Yellow River Delta Biomass energy in Yellow River Delta mainly includes rural biogas digesters and biogas engineering. In 2011, digester gas production of Dongying was 17,485,600 cubic meters and it was was 19,879,000 cubic meters in Binzhou, and the total valued was approximately $ 6,158,500[7]. The utilization of rural biomass energy in Yellow River Deltain 2012 is shown in table 1.

Table 1 The 2012 utilization of Yellow River Delta rural biomass energy

Area	Total biogas production, (km^3)	Biogas Users, thousand households	Biogas projects （Pool capacity above 300 kilostere）
Dongying	1525.78	66.4	9
Bingzhou	2288.90	67.7	7
Laizhou	519.22	10.8	6
Shouguang	560.34	1.08	8
Changyi	777.78	1.58	3

The use of crop straw and marginal land The main crops in Yellow River Delta are cotton, corn, rice, wheat and soybeans [8]. Cotton cultivation area is 333 thousand hectares, and annual yield of cotton stalks is about 1,875,000 tons. corn acreage is more than 286.7 thousand hectares, with annual output of corn stalks about 770 million tons[9]. The proportion of crop acreage of various types is illustrated in Figure 1. The residue to product ratio and the standard coal coefficient of different crops are shown in Table 2. According to the actual situation of cotton biomass in Yellow River Delta, the annual output value of marginal land in Dongying and Binzhou City is calculated (cotton yield of 1500kg per hectare in this calculation,Table 3).

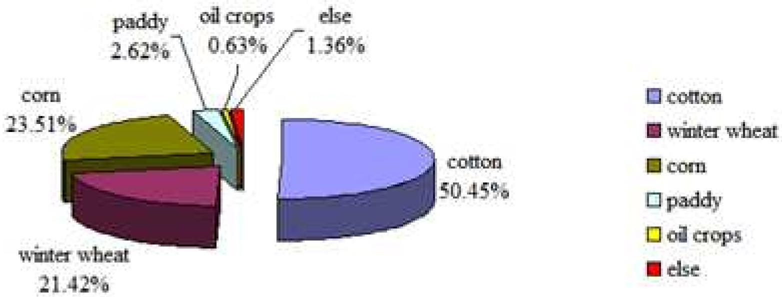

Fig.1 The proportion of various types of crop acreage in Dongying city[10]

Table 2 The residue to product ratio and the standard coal coefficient of different crops [11]

Items	Winter wheat	Paddy	Corn	Cotton	Oil crops
RPR	1.1	0.9	1.2	3.0	2.0
SCC	0.500	0.429	0.529	0.543	0.529

Table 3 The theoretical annual output value of marginal land in Dongying and Binzhou City

Items	Marginal land area, (ha)	Cotton yield (t)	Output of cotton stalks, (t)	Amount of standard coal equivalent, (t)
Dongying	274,000	411,000	1130,250	565,100
Binzhou	120,667	181,000	497,750	249,000
Total	394,667	592,000	1628,000	814,100

Energy crops

Research of energy crops has a crucial role for biomass energy scale and industrial development. In 1998, a book "Energy Plant Species"was published, and in this book, 16 kinds of "energy plants" such as *sweet sorghum*, *cordgrass*(*Spartina* spp.), *Phragmites australis Trin* and etc., were introduced [12].

Energy crops classification According to the material component of energy carrier, energy crops can be divided into 3 categories: ①Starch and sugar crops, for the production of fuel ethanol; ②Oil crops, used to generate biodiesel; ③Lignocelluloses crops, converted into thermal energy, electricity, ethanol and biogas[12].

Starch and sugar crops The capacity to produce fuel ethanol are different in different crops, as shown in Table 4. Raw material for fuel ethanol in China is mainly corn and wheat aging, while corn in U.S and sugar cane in Brazil [13]. As shown in table 4, sugarcane, sugar beet and sweet sorghum have a strong fuel ethanol production capacity, which makes them as an important research goal in many countries. Sugarcane varieties of short growing season and high yield such as H69-9103, L79-1002, EMS145, EMS245 and etc. have been bred out in U.S. and Indian [14,15]. Chinese bred varieties of sugarcane as a fuel ethanol is Guifu 97-18. Recently, sweet sorghum varieties with high sugar content and strong resistance are Rio, Roma, Bailey, Cowley, BR-504, BXH34-3-1, and etc. However, dependence of fuel ethanol on food crops increased the contradiction between population growth and the food crisis.

Table 4 The starch and sugar crops and their ethanol productivity

crops	Single yield ($t \cdot ha^{-1}$)	Sugar/starch content (%)	Sugar/starch production ($t \cdot ha^{-1}$)	Ethanol production ($L \cdot ha^{-1}$)
Zea mays	6.9	65.0	4.49	2 874
Triticum aestivum	7.2	62.0	4.46	2854
Cichorium intybus	35.0	16.0	5.60	3248
Solanum tuberosum	32.4	17.8	5.77	3693
Saccharum officinarum	80.0	10.0	8.00	5400
Beta vulgaris	57.4	16.0	9.18	5600
Sorghum bicolor	90	10.0	9.00	5400

Oil crops Oil crops is herbs or woody plants and used for extracting the oil. The domestic energy plants were listed in table 5. Nowadays, *ricinus communis*, *glycines max* and *brassia campestris* have already achieved commercial cultivation to produce biodiesel. In order to meet the increasing demand of biodiesel, the oil crops research has been deepening. According to reports, growth in the Australian adult Cuban tree (also known as the diesel tree), about 25 L of fuel oil can be obtained from them per year. growth oil, each of China's Hainan Nan trees can annually produce 10 L - 25 L biodiesel, one kind of Brazil fragrant gum trees a year, secrete 40 kg ~ 60 kg glue, which clean the glue not be treated may directly as oil use [16]. there are 1.05 million jatropha trees in Sichuan Province, China, and average seeds yield is 1.5kg each plant.Seed kernel oil rate is 50.0% ~ 61.2%, andthe annual production of jatropha oil is 2250 ~ 3000kg per hectare [17,18].

Table 5 Major oil crops and productivity [12]

crops	grain yield ($t \cdot ha^{-1}$)	oil length (%)	Oil production($t \cdot ha^{-1}$)
Gossypium spp.	1.20	15-25	0.29
Ricinus communis	1.20	50.00	0.6
Crambe abyssinica	2.00-3.50	30-45	0.74
Cocos nucifera	4.17	36.00	1.50
Elaeis guineensis	30	26.00	7.80
Helianthus annuus	2.50-3.20	35-52	0.88-1.67
Arachis hypogaea	2.00	45-53	1.00

Lignocellulosic crops Lignocellulosic crops can be used as the energy source of bio-ethanol, bio-gas, heating,power generation or generate electricity.Main lignocellulosic crops and their yields and energy balance are displayed in the table 6.

Compared with traditional crops, lignocellulosic crops with better resistance and adaptability to marginal land are more suitable to be used for the development of marginal land. Researches showed that *medicago* at 0.3% salinity can still grew normally and each one kilogram of fresh *medicago* obtained 300 grams residue and 100 grams ethanol after crush [19,20]. Europe has bred the triploid giant *miscanthus*. This plant height is 7 - 10 m, and theoretical yields is up to 22 tons per ha, while calorific value is 18.2 MJ each kilogram.

Algae biofuels Algae are referred to as "the third generation biofuels" because ofthe production of biodiesel and algae hydrogen [21]. Microalgae was originally designed to stabilize atmospheric CO_2 content and reduce global warming.

However, it received a lot of national attention because of its characteristics of non-toxic and non-sulfur, high productivity and benefits to the environment. It is estimated that in 2020, 30% of the algae biofuel can be used to produce petroleum distillates, and the annual production of algae biofuels will increase to 6 billion gallons in 2025 [22]. Algae also can provide a wide range of valuable products, such as ω-3 fatty acids, animal feed, energy resources, organic fertilizers, recombinant proteins, drugs and vaccines [23,24].

Table 6 The yield and capacity characteristics of major ligocellulosic crops [25]

crops	yield of Fresh weight, $t{\cdot}ha^{-1}$	Share of dry matter,%	energy content , $GJ{\cdot}t^{-1}$	Energy outputs, $GJ{\cdot}ha^{-1}$
Sweet sorghum	50-100	23-35	16.7-16.9	250-422
Arundo donax	45-110	35-40	16.5-17.4	240-600
Miscanthus spp.	40-70	35-45	17.6-17.7	260-600
Panicum virgatum	25-60	35-45	17.4	174-435
Hibiscus cannabinus	70-100	25-35	15.5-16.3	155-326
Cynara cardunculus	25-35	40-45	15.5-16.8	155-252

The discuss of planted feasibility of several energy crops on marginal land in Yellow River Delta Since the marginal land in Yellow River Delta has characteristics of low organic matter content, lack of soil nutrients and serious salinization, traditional agricultural production has been greatly hampered. Breeding salt-resistant, drought-resistant and well- adapted energy crops become new ideas for marginal land exploitation.

Studies showed that *ricinus communis* can normally grow at 0.4 percent salinity, and the low concentration of salt treatment was in favor of seed germination [26,27]. Experiments indicated that the average yield of *ricinus communis* of saline soil plots was up to 5.4 tons per hectare and soil desalination rate was 51.95 percent after planting *ricinus communis* for 3 years [28]. *ricinus communis* was considered as the most promising plants for soil remediation and biodiesel production. , *switchgrass* has vigorous growth ability, developed root system, strong pest resistant and easy to harvest, and can well grow in poor soil and saline alkali area along with the salt tolerant threshold of 178.6 $mmol{\cdot}L^{-1}$[29]. *Switchgrass* biological yield was up to 20 tons per ha, the calorific value of dry basis of switchgrass per kilogram was approximately 14.5 MJ, which was equivalent to 70% -80% of the same quality coal[30]. *Sweet sorghum* is also called "second-generation *sugarcane*." The NaCl concentration range of *sweet sorghum* tolerance is 0~550 $mmol{\cdot}L^{-1}$, and the salt tolerance is different in the varieties. BJ-18 is a strong salt tolerance variety [31]. China has a total of *sweet sorghum* resources in 374 place, of which 159 landraces copies and four pairs CMS lines and maintainers [32].Certainly, cultivation technology, transportation and policy are also crucial for marginal land development as well as for the breeding of good varieties.

Conclusions and future prospects

Marginal land exploitation with biomass energy production has tremendous social, economic and ecological benefits. Research on energy crops is still in the initial phase, while transgenic approaches for increasing plant salt tolerance are demonstrated to be feasible. In order to reduce the dependence of energy crops on cultivated land, marginal land will become a hot issue of future development. The following points should be carried out for marginal land utilization and biomass energy development :① combining energy crop breeding with biotechnology; ② combining government's policy with biological energy engineering;③ combining large-scale cultivation with agricultural enterprise; ④ combining state subsidy with rural biogas.

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